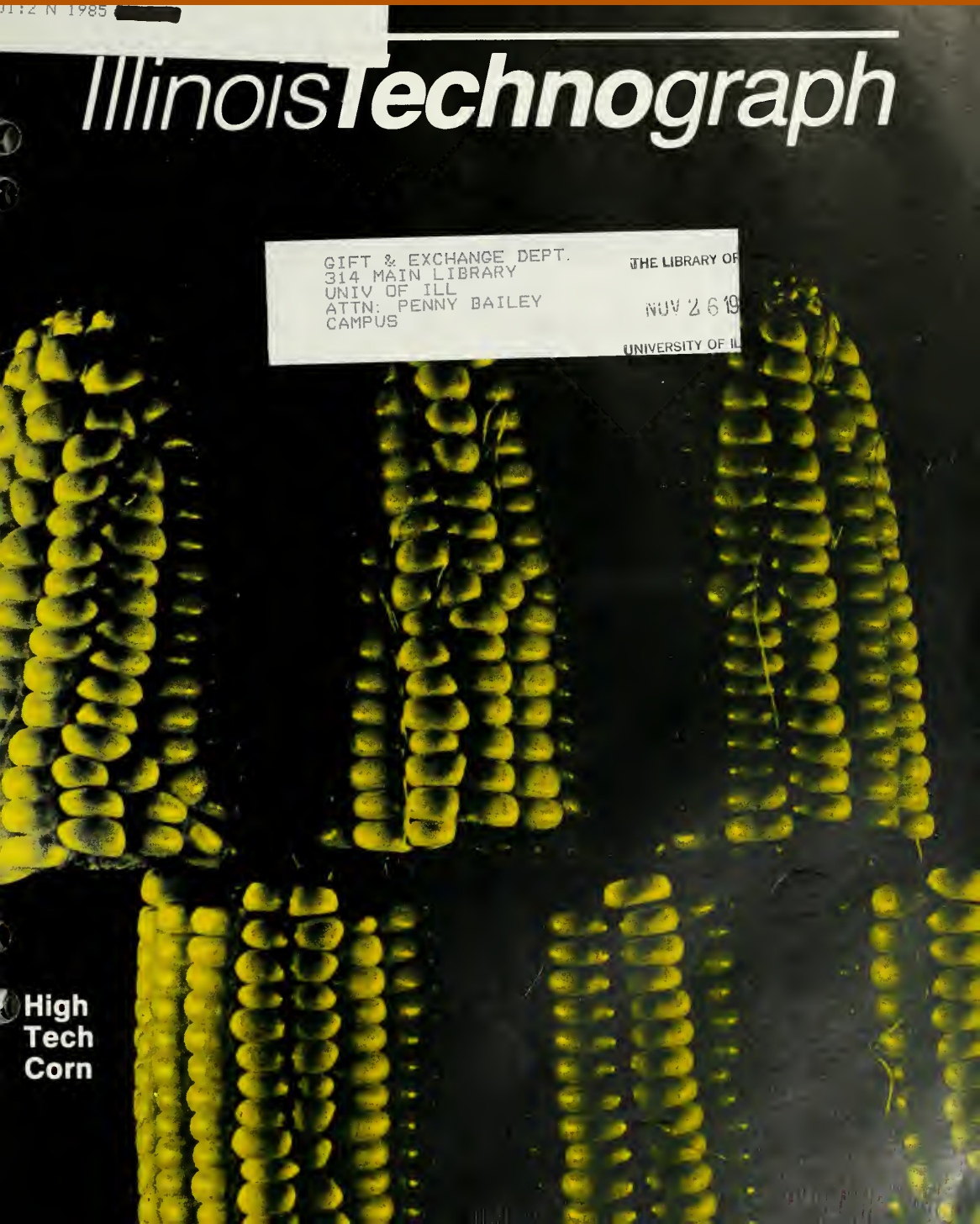
Illinois Technograph



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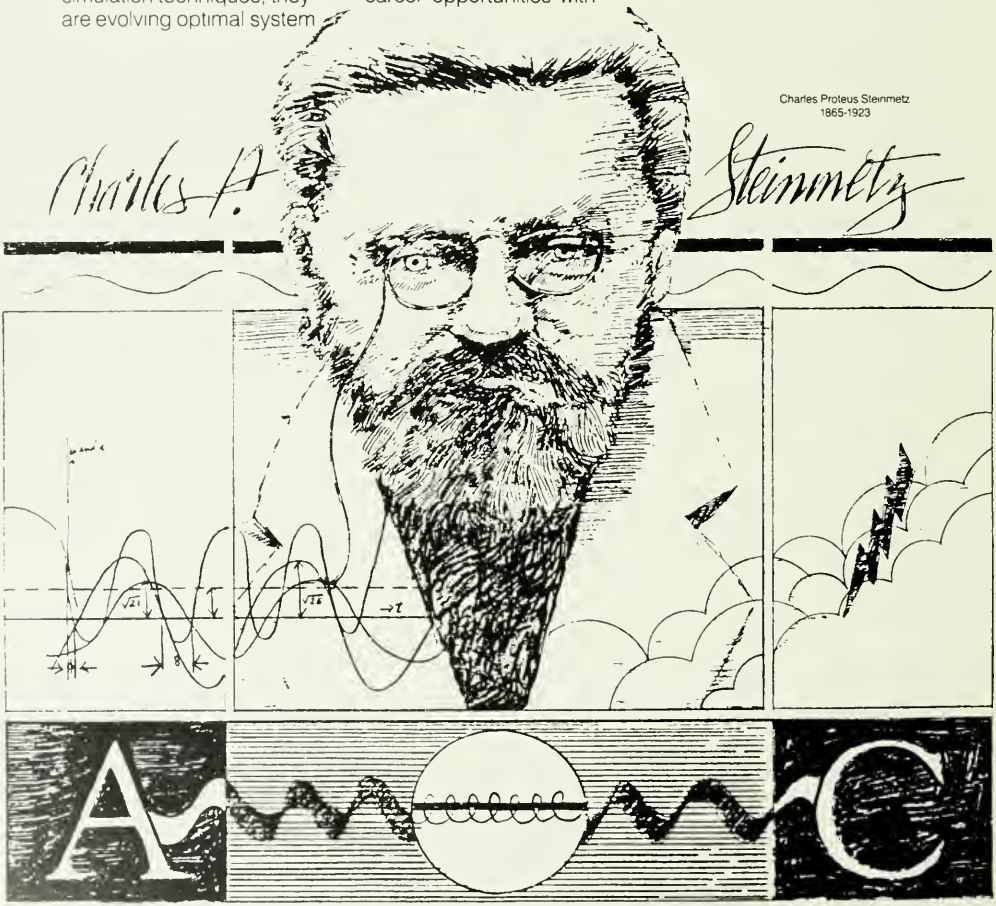

The feasibility of turning sea water into electricity is being studied in fusion energy experiments at Kyoto University in Japan. The studies involve a Hughes Aircraft Company gyrotron, a microwave tube that uses a spiraling stream of electrons to produce extremely high power microwave frequencies. Fusion energy holds tremendous potential because its source of fuel (hydrogen) can be extracted from sea water. It could produce large amounts of power with little or no radioactive waste and no threat of meltdown or explosion. In fusion energy research, the gyrotron's high-power radio waves heat hydrogen particles (plasma) to temperatures of tens of millions of degrees. These particles fuse under pressure, causing a thermonuclear reaction that provides energy for driving steam turbines.

A new technique may expand the use of lasers in commercial and military applications. The approach, called optical phase conjugation, is considered a major advance in optics because it offers a solution to distortion problems that have limited the use of lasers. When a laser beam passes through a turbulent atmosphere or a severely strained optical component, the beam is distorted and the information it carries is degraded. The Hughes technique, however, forces the laser to retrace its path through the distorting medium so the beam emerges free of distortion. The method eliminates the need for complex electro-optical and mechanical components to correct the distortions.

A MIDAS touch will create the factory of the future by introducing computer technology throughout one Hughes manufacturing division. The new Manufacturing Information Distribution and Acquisition System (MIDAS) is a flexible, high-speed data communication network. It will transmit and gather millions of bits of data per day by linking computer terminals, laser printers, bar-code scanners, and other equipment. MIDAS will serve graphic workstations and facilitate paperless planning. Similarly, it will relay numerical-control programs from main computers to machines in the factory, eliminating the need for paper tape. MIDAS will let all users share important peripherals, such as a laser printer, which now is impossible due to the incompatibility of equipment from different manufacturers.

NASA's Project Galileo, which will explore the planet Jupiter later this decade, must arrive at a precise angle if it is to carry out its measurements of the chemical composition and physical state of the Jovian atmosphere. The Hughes-built probe will arrive at 107,000 miles per hour, fast enough to travel between Los Angeles and Las Vegas in nine seconds. If the probe hits at too shallow an angle, it will skip off into space; too steep, it will be reduced to ashes. Even at the proper angle, the probe will encounter extremes never before faced by spacecraft. In less than two minutes, much of the forward heat shield will be eroded by temperatures of thousands of degrees. With atmospheric entry forces reaching 360 times the gravitational pull of Earth, the 742-pound probe will take on a weight equal to an empty DC-10 jetliner. Project Galileo is scheduled to be launched from the space shuttle in May 1986 and to arrive at Jupiter in August 1988.

Hughes needs graduates with degrees in EE, ME, physics, computer science, and electronics technology. To find out how to become involved in any one of the 1,500 high-technology projects, ranging from submicron microelectronics to advanced large-scale electronics systems, contact Corporate College Relations Office, Hughes Aircraft Company, Dept. C2/B178-SS, P.O. Box 1042, El Segundo, CA 90245. Equal opportunity employer. U.S. citizenship required.

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November 1985 Volume 101, Issue 2

Illinois**Technograph**

On the cover: As American as apple pie and baseball, midwest corn represents dinner for some and a way of life for others. (photo by Mike Brooks).

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Editorial

Revenge of the Nerds

I'm not sure when the trend began, but it seems that engineering students have always been a target of abuse for their classmates who spend their time decorating their textbooks in various neon hues south of Green Street.

You know the kind of abuse I mean. It's the stereotype that labels us with such endearing terms as squid, goob, enginerd, snoid, and dweeve, and these are just the printable ones. It's the image that makes "engineering party" a paradoxical phrase and "engineering fashion" suggest an ensemble of cropped pants and white tube socks.

As members of this much maligned group, we know that this is not a well-fitting image and that these slurs are completely undeserved. Our rationale is not that pocket protectors are really valuable in protecting ones shirts from horrid ink stains, or that only GE 103 students publicly display T-squares, or even that perhaps if the rest of the campus knew the joys of spending Friday nights drawing force diagrams, debugging assembler code, or deriving the heat equation, the bars would close for lack of business. We are able to apply the scientific method and prove definitively that engineers are truly a fun bunch.

We start, as all good proofs do, with the base case; show that $n = 1$ is true. So I asked a friend of mine what she would do if her mission was to have an incredibly fun time in Champaign-Urbana, Illinois in November, 1985.

"Well," she said, "I suppose I'd sleep until noon and then spend the afternoon at a football game. After dinner I guess I'd go out on a date with a really great guy."

I asked her to elaborate on what a fun date would be.

"Well, you know, we'd go to a movie, maybe grab something to eat, and then, well, you know..." She smiled.

Well, it was quite obvious to me how indebted she was to engineers for her perfectly fun day.

In order to see the football game, she had to go to Memorial Stadium, which was designed by an engineering alumnus. Now, while she knows enough about football to distinguish a field goal from a touchdown, she certainly doesn't know all the referee signals, which means she relied on the audio system to let her know what was going on. She also didn't bring her own scratch pad to keep track of the score, signifying that she kept an eye on the electronic scoreboard in order to be informed. The application of various engineering products was necessary in order for the game to be fun for her.

It's incredibly obvious that in order to see a movie, she had to rely on the work of engineers. Sure it took talented actors, directors, and costumers to put the performance together, but there would be no way for their creativity to be displayed on a national level if engineers had not developed movie film, projectors, and Dolby sound. Even in an artsy activity, engineers play a key role in providing fun.

As for "grabbing something to eat," it's not the cooks who prepare the food or the copy writers who extol the freshness and purity of the product on the package who are responsible for making sure that you don't die of botulism or ptomaine poisoning when you open a bag of doritos. No, it's the engineers who monitor factory production and who design protective packaging who make sure that eating is fun for you.

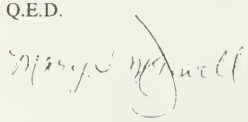
Moving on to the inductive step of the proof, or showing that the theorem holds for all n, one of the most popular American pastimes is TV watching. The country spends millions of hours per day glued to an electronic screen. Who do you think is responsible for bringing that pleasure to his fellow citizens? I'll give you a big clue: an archeologist did not find a television among the ruins of the Acropolis and later sell it to RCA to be used as a prototype for mass production.

What was true of my friend's date at the movies applies to popular music too. Where would Bruce Springsteen be without the technology to create albums bearing his Levi's covered posterior on the cover that are played everywhere? Who would be able to hear him without sophisticated sound equipment, and what would he sound like with an acoustic guitar?

When you go to an amusement park, do you expect to be handed a great work of literature to wile away the day and thereby amuse yourself? Do you get to spend the day balancing accounting records? Not usually. Instead, you pay approximately $15 to experience forces, momentum, rotations, gravitational pull, and many other manifestations of mechanics guaranteed to permanently rearrange your internal organs. The country turns *en masse* to freshman-level physics to have a good time.

The proof seems very conclusive. It is not only a misnomer to depict engineers as slide rule toting study hounds, it is a great injustice. It is only through their engineering skills and knowledge that anyone else is able to have a great time. My friend would have had a rotten perfect day if not for modern technology, as all of her fun activities required an engineer—even, in her case, the smile.

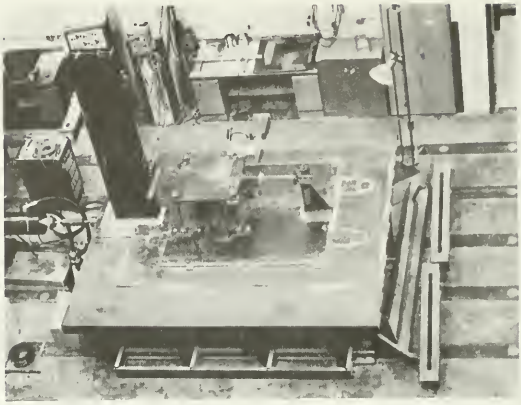
Q.E.D.



Illinois Technograph **invites letters in response to its articles and editorials, or eny other items of interest to its resdership. Articles, photographs, end other contributions will also be considered. Letters must be signed, but names will be witheld upon request.**

Averting Earthquake Disasters

Earthquakes may be one of the least feared natural disasters in the midwest, but the centering of civilization on fault zones has brought new attention to the design of safe buildings. Using sound engineering techniques, structures can be built to ride out a queke, rather then crumble.



The "shaker," located in the crane bay of Newmark Lab, is used test building designs by subjecting models to the kind of motion encountered in an earthqueke (*photo by Mike Brooks*).

Late in September a force of tremendous destructive potential was unleashed from just below Mexico's Pacific coast. As this force ripped through Mexico City, the infrastructure of that city was reduced to an entanglement of rubble, chaos, and human tragedy. But this need not have been so. Since the early 1970's, enough has been learned about earthquakes and the destruction they can bring that structures can be designed to withstand their tremendous force.

Earthquakes cause damage by inducing motion in structures, by disrupting the stability of soil and rock and by setting earth and water into violent motion. Of these effects, the most apparent is the motion induced in structures. Acceleration of a structure designed primarily as a static body creates forces which can greatly stress components to the point of failure, cause structural elements to move into ineffective positions, and damage building contents and adjacent structures by impact. As a building is accelerated in a horizontal direction, its inertia resists motion and shearing stresses are induced in vertical supports. If the center of mass of each level does not coincide with the center of rigidity of the resisting system, a torque is caused and twisting of the structure results. Structural elements, such as bridge girders, may be shaken from their bearings or rotated to a position which is far less capable of resisting bending.

Disruption of the integrity of the ground occurs in two manners. The ground may develop discontinuities, causing underground structures to be sheared, heaving of pavements, and moving of the foundations of structures. Longitudinal movement of bridge foundations can result in the bridge buckling or the girders falling off their supports, either being quite unacceptable. Another form of ground failure is liquefaction of a soil. Liquefaction is a term applied to the transformation of soil into a fluid state. As the soil vibrates, pressure develops in the water in the soil. The individual soil particles lose contact with each other and the soil loses shear strength. Without shear strength the soil acts as a fluid in which dense items sink and buoyant items (underground tanks and pipes) rise toward the surface.

Landslides and large waves are often instigated by earthquakes. Mudslides and falling rock result in the overwhelming and undermining of roads, buildings and other structures. Also, impacts from falling rock can damage critical members of a structure thereby causing failure. When a quake originates under a body of water, a tsunami or seiche may result. A tsunami is a fast moving, low ocean wave that rises to a great height when it reaches the coast. Coastal geometry may cause localized amplification of such a wave. A seiche is a similar occurrence on an inland body of water. In addition to damage incurred from the impact of the wave, flooding of coastal areas and adjacent waterways causes damage.

With increased urbanization comes an inherent increase in the potential loss of life and property. Estimates of losses if a great quake were to strike southern California or the eastern United States are tens of thousands dead and tens of billions of dollars in damage. Technology has developed primarily since the San Fernando earthquake in 1971 and is sufficient to prevent much of the damage and death that would occur.

The prevention of damage begins with the mapping of potential hazards. Methods used include the simple accumulation of data from past earthquakes, as well as evaluation of the present state of an area. Sets of aerial black and white photographs producing a three dimensional image are used to identify regions of seismic activity such as fault zones and areas susceptible to ground failure such as alluvial fans, dried stream channels and areas with unstable slopes. Satellite infrared photos are also used to determine

Jeff Hamera

slope instability and liquefaction potential by evaluating the water content of the soil. Liquefaction potential can also be evaluated by soil testing. Monitoring fluctuations of magnetic fields can also reveal areas of seismic activity. Another remote sensing technique involves transmitting acoustic waves through the ground and monitoring the reflections for evidence of discontinuities beneath the surface. Carbon-14 dating methods determine the frequency of past fault activity and evaluate the present state of strain and the shear modulus of the rock along the fault, which helps to determine the likelihood of activity.

While identifying impending quakes is possible, the exact prediction of occurrences is not. By performing analysis on historical data and by monitoring ground motion, magnetic behavior, and animal behavior, analysts can give some warning of an earthquake. However, these warnings can be inaccurate and can damage the economic activity in an area.

Forewarning of quakes is important in saving lives, but a general model of potential seismic activity is usually sufficient for engineering purposes. Engineers are most concerned with the type of ground motion that can be expected and with what frequency it can be expected. Strong motion accelerometers are used to record movement that will induce forces in a structure. This data is combined with historic and geologic data to derive a probability model that is used to determine the magnitude of ground motion for a specified return period. Return periods vary from 50 or 100 years for typical structures to 500, 1000 or 'largest probable' for critical structures such as nuclear reactors and large dams.

A number of approaches to preventing damage in structures have been made. Basically, a structure may be designed to be ductile, to deform without failure, or to be rigid and overpower an earthquake. One effective way of resisting earthquakes is using a steel moment frame. This system is ductile and rigid and therefore allows the distribution of concentrated effects which would otherwise damage the structure.

Reinforced concrete shear walls provide effective resistance by providing large resistance to both the horizontal motion effects and the amplification of forces that occurs when the period of vibration of a structure coincides with that of the tremors.

A hybrid of these two systems produces a building with the ability to sustain its integrity under large forces and the ability to reduce the effects of these forces. Reinforced concrete columns that have only longitudinal reinforcement are particularly vulnerable because they lack ductility. However, if helical reinforcement is used, concrete within the steel is confined and greater strength and ductility are gained.

Flexible systems must be designed so that the natural frequency of the building is not that of expected tremors. The natural frequency is determined by modeling the building as a cantilevered beam with point masses at each floor. A dynamic analysis of the approximated structure is then performed. If the periods are allowed to synchronize, the contents of the structure may be thrown about, damaging property and endangering occupants. Also, permanent deformation of the building may occur. If this happens, columns will experience bending for which they are not designed and will be overstressed.

Designing against torsion involves the development of a seismic resisting system which has a center of rigidity, the point around which torsion will occur, that is coincident with the center of mass of the structure. The center of mass of a building is variable and for each level it may vary. Also, the resisting system may vary causing discontinuities which are undesirable. The best solution available is an experienced designer who will minimize and account for these effects according to the needs of a particular structure.

An innovative solution to earthquake design involves isolating the foundation by placing the structure on a shock absorbing system. While this system is effective, standard building practices can achieve satisfactory results. One such system employs large steel and rubber cylinders to absorb tremors before they affect the structure. Another uses large steel spheres as bearings, allowing the ground to roll beneath the building without inducing inertial forces. These systems have been used more abroad than in the U.S., but they are gaining acceptance in the western states.

Earthquake resistant design is possible today. The technology has been available for several years and building codes have reflected the need for such design. But without the threat of an imminent disaster, the added cost of earthquake design does not seem necessary. Many building codes in regions where earthquakes are rare have been slow to adopt earthquake design requirements and slower yet to enforce them. Many think of earthquakes happening in California or Japan or on television, but the largest earthquake to be recorded originated south of St. Louis and rocked the midwest for months. ■

Finding Square One

The Engineering Placement office provides graduating engineers and those seeking summer employment with a means to find the perfect career path.

Top, Dennis Fey, senior in mechanical engineering, checks his interview schedule with the list outside the placement office. Below, Susan Bowery, secretary for the placement office, assists Randy Smith, also a senior in mechanical engineering (*photos by Mike Brooks*).

Except the lucky few with inside job connections and those who are graduate school bound, everyone graduating from the College will use the Engineering Placement Office (EPO). In the quest for permanent or summer employment the EPO provides the initial contact between student and company recruiter and organizes the crucial interview.

Room 109 of Engineering Hall houses the EPO which is open from 8-5 Monday through Friday. The phone number is 333-1960. Inside, a large table and a reception desk dominate the room. Several staff members work at the reception desk answering questions and collecting resumes. Small interview rooms encircle the main room. At the large table students copy company addresses and complete interview request cards. On shelves throughout the room, binders hold literature on hundreds of companies.

Engineering students one or two semesters away from graduation may use the EPO in the pursuit of permanent employment. Even though companies generally look for juniors and seniors for summer positions, freshman and sophomores can also use the EPO. The role of the EPO in summer recruiting is smaller than for permanent recruiting, but it is still helpful.

The road to permanent employment begins when the job seeker goes to the EPO and picks up a standard placement data sheet along with a set of instructions for its completion. After returning twenty copies of the resume to the EPO, saving

J e f f r e y D o b o s

about thirty copies for future use, the student receives a copy of the current placement manual, computerized interview request cards, and a registration number.

The placement manual should answer all questions the job seeker might have. A summary of EPO services, pages and pages of interview do's and don'ts, a list of companies recruiting, the dates they will be on campus, and interview sign-up instructions make the manual very helpful. In addition to the placement manual several orientation sessions are provided in the begining of each semester. Also, during the semester the EPO conducts meetings which discuss interview preparations, plant trips, technical sales, and manufacturing engineering.

To keep information current, weekly bulletins available in the EPO update the placement manual. The bulletins also contain descriptions of the jobs recruiters need to fill. Day to day updates are posted on a bulletin board right outside the office in the hallway. If a student misses an interview, however, future use of the EPO will be denied unless an acceptable explanation is given. The office requires forty-eight hours advance notification of cancellation, otherwise it is considered a no-show.

So, you have the latest weekly bulletin and you see employment possibilities with ABC, Inc., now what? As the next step the student completes an interview request card and returns it to the office before Wednesday of that week. On Friday a list posts the results of the request outside of the office. If the request is granted, the interview's time and place shows. The student must then place a copy of their resume in the company's slot before the interview. Company slots are located in the hallway outside of the office. The prudent student will consult the bulletin board every day for changes before the interview.

To help prepare for the interview, many guides are available to the student. The placement manual contains many pages of advice including a section on the ethics of interviewing. In addition to the manual, stacks of handouts sitting on the reception desk in the office contain even more guidance. Each source stresses the need to know as much as possible about the company. The EPO helps out by providing a library of literature on over seven hundred companies. Also, numerous handbooks and directories in the office provide additional material. For student convienence, information on companies interviewing that week is set out in a special bin on the south wall of the office.

In addition to assistance in finding permanent employment, the EPO provides assistance for summer employment seekers. Starting in the fall, a bulletin printed on blue paper is released about every other Monday. The bulletin is located in a slot on the far right of the south wall in the EPO. The sheet lists companies looking for summer employees and describes requirements for candidates. Usually the contact between student and company is by mail. A resume sent along with a cover letter is fine. Occasionally a summer recruiter will be on campus collecting resumes and interviewing. Summer employment is very competitive, so be sure to pick up the blue bulletins on the appropriate Mondays.

The EPO also provides counseling for students. A conference can be arranged to answer questions on career choices, resume preparation, interview preparation, and other pertinent topics.

In return for their services, the EPO receives information from students and recruiters on job offers, salaries, and final career decisions. A release form must be completed by everyone using the office which asks for the above information.

The main goal of the EPO is to sign-up students for interviews, after which the EPO offers advice on how to conduct oneself during the interview. Remember, responsibility for landing a job comes right down to you. ■

From page 7

Tech Teasers Answers

1. Since the wheels of the car rotate while it is moving, at any instant the point at the bottom of the wheel is stationary, and at the next instant the same point actually moves backwards.

2a. All the Greeks on campus should be ashamed if they didn't get this one: Alpha, Beta, Gamma, Delta, Epsilon...Zeta.

b. 120-132-242 is the calculus sequence we all have to take.

c. If you replace all the letters in TECHNOGRAPH with the next one in the alphabet you get UFDIMPHSBQI. So the missing letter is I.

3. Snow White and the Seven Dwarfs (in alphabetical order): Bashful, Doc, Dopey, Grumpy, Happy, Sleepy, and Sneezy.

4. $999 \times 999 + 999 = 999000$

The problem can be represented by:

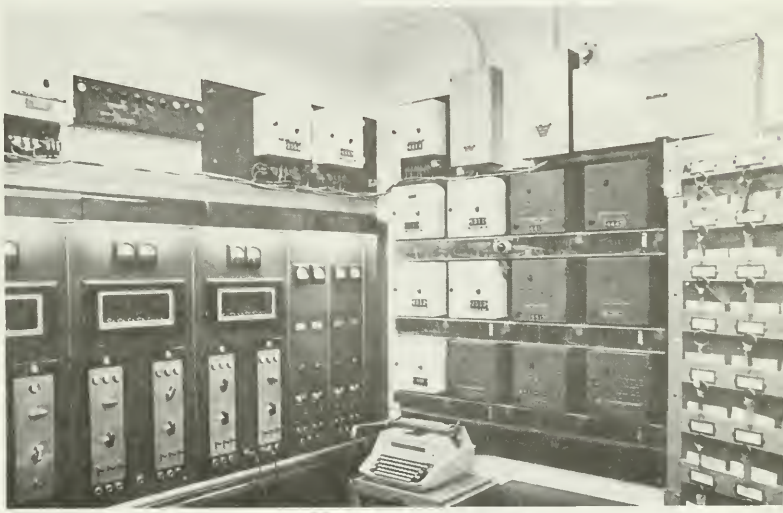
$$(100x + 10x + x)(100x + 10x + x) + 100x + 10x + x = 100{,}000x + 10{,}000x + 1000x + 100y + 10y + y$$

where x and y must be integers between 0 and 9. This reduces to $111x(x-9) = y$. Since 111x and y are non-negative, $x - 9$ has to be non-negative. This can only happen if $x = 9$. $111 \times 9 \times (9-9) = 0$, so $y = 0$.


DEPARTMENT

Waiting

Judging from the mayhem that the University Fire Department creates when they go out on a call, it may appear that life at the fire house, at far left, located between Engineering Hall and Mining and Metallurgy, has hardly a dull moment. But most of the job amounts to waiting. Lower left, fire fighters Joe Franks and Mike Rumer prepare a meal; their work clothes stand nearby, at left. All this time, the various fire alarms are ready, prepared to let them know that their services, right, are required (*photos and text by Mike Brooks; fire photo courtesy The Daily Illini*).



Improving Illinois Corn

Illinois has always been a leader in corn production. Now, techniques developed by a University researcher could improve the quality of this commodity and increase its market value.

The University's College of Agriculture has long maintained a world-wide reputation as being one of the most innovative institutions in the sphere of research and development. Today, much work continues in areas that directly affect the ailing Illinois farm. These projects could eventually not only increase the productivity but also improve the quality of the goods. Currently, Professor M.R. Paulsen, an agricultural engineer with the University, is actively researching one method that he hopes will increase the marketability of Illinois corn.

Stress cracks within the corn kernel are an inherent characteristic of the type of corn grown in the United States. Rapid, high temperature drying leads to an even greater number of cracks in the kernel, thus increasing the grain's susceptibility to mold and fungi invasion. The storage life of the corn is decreased, and these cracks result in increased kernel breakage which contribute to dust explosions in areas where the corn is stored. The types of corn grown in countries such as Argentina also develop stress cracks, but Paulsen believes that in such corn, the cracks apparently present less of a problem. For many specialized food processors such as corn starch manufacturers, using corn with a minimal number of cracks helps to increase the recovery of starch. Thus, for the same amount of corn, the manufacturer gets a greater amount of starch. Detecting these cracks before the grains are sold to end-users would allow the corn to be classified on a "quality" basis. By purchasing American corn, a buyer would be reassured of the quality of the commodity he is getting. This may encourage the buying of American corn; thus increasing Illinois corn exports.

Originally, Paulsen and a graduate student set out to detect the presence of these cracks through the use of a laser-beam. In this apparatus, a laser-beam is focused through an objective lense onto a single kernel. The light first passes through a beam splitter, where fifty percent of it is lost. Upon hitting the kernel, different intensities of light are reflected. For example, the white, cracked starch area reflects a higher intensity light than does the yellow, uncracked area. The reflected light is directed into a photomultiplier tube, and information is then fed to a plotter where a graph of the varying intensities is made.

Paulsen, however, was not satisfied with the results of the laser beam apparatus. Because the narrow laser beam focuses onto a very small area of the kernel, only those cracks enclosed by this very small area are detected, while those outside of this area are not. Explained Paulsen, "[Using this apparatus,] it is very difficult to judge the extent to which an entire corn kernel suffers from stress cracks."

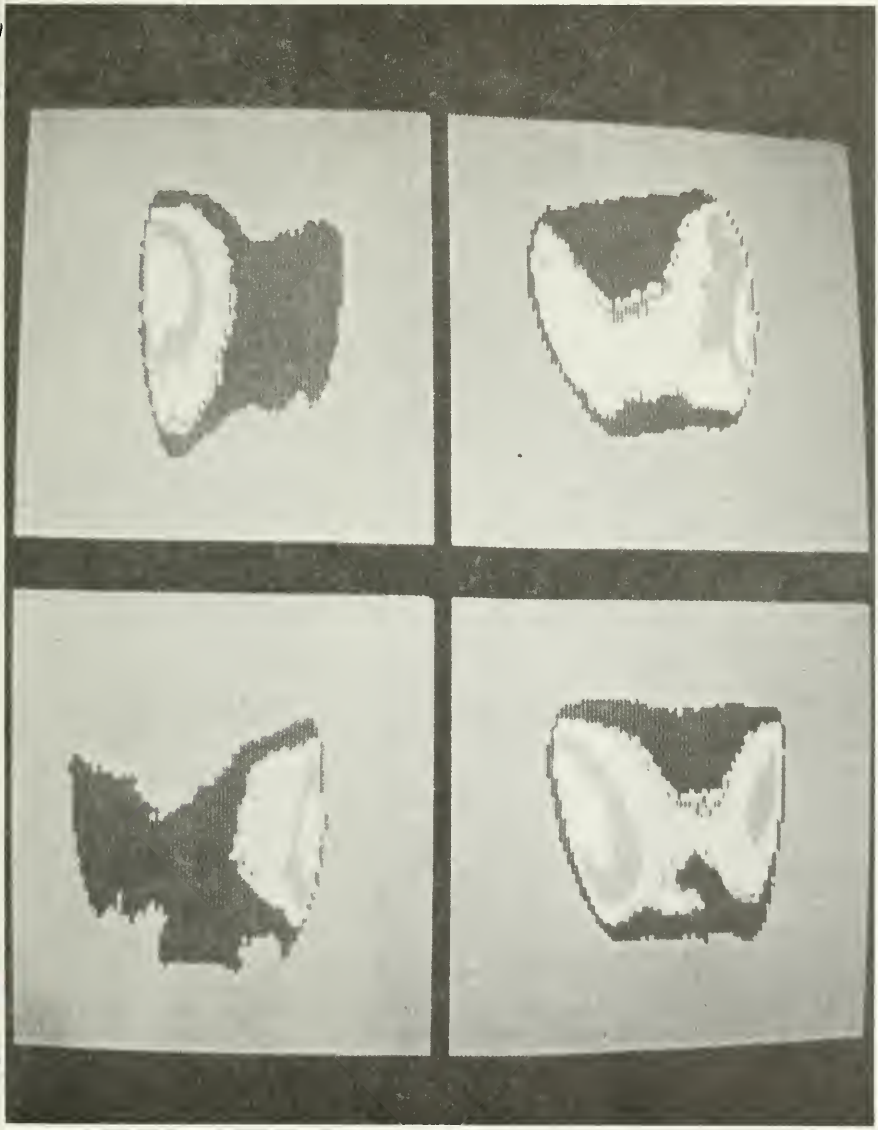
A new computer-vision system developed by North Carolina State University's Biological and Agricultural Department overcomes what Paulsen believes are the shortfalls of his laser beam apparatus. The system relies on a camera through which light shining on an entire corn kernel is reflected. The reflected light then travels to a photodiode array which senses its intensity. Information is then fed into a controller where the analog signal is converted into a digital signal. The digital signal then goes to a computer where the image of the kernel is produced on a color monitor with varying intensities of light.

Paulsen is currently in the process of constructing a similar system here at the University. The expected development cost of the system is approximately $20,000. Though the system is clearly superior to the original laser beam apparatus, Paulsen believes that much work still needs to be done on suiting the system for widespread use. For example, the system as it now exists only senses the intensity of reflected light and displays it on a monitor. Because differences in light intensity can result from discoloration and mold, as well as stress cracks, a person needs to stand by and decide exactly what the image on the monitor means. Paulsen eventually wants to develop a completely automated system that would allow the computer to interpret the data and make a decision by itself.

His plans call for a computer-vision system to be paired with a conveyor belt. The corn kernels would move on the conveyor belt under an overhanging camera lens which will take one-thirtieth of a second to form an image. The information would then pass to the computer, where a decision as to the extent of damage to the corn would be made.

A great deal of attention has been focused on Paulsen's research by both academia and industry alike, and he is optimistic about receiving funding for his project this year. Whether this project will prove to be cost effective remains to be seen. It is still questionable whether manufacturers will be willing to pay the higher price for their corn in return for the assurance of quality and a greater yield per kernel. In any case, Paulsen's research is evidence that work is continually under way at the University to further develop Illinois's most indigenous of industries, agriculture. ■

Ashraf Hameedi



At left is a computer enhanced image of visible light through several kernels of corn. Those furthest left have been fractured and have opaque zones, unlike those further right which have not been fractured (*photo courtesy M. R. Paulsen*).

*Tech*notes

Spend a Year in Germany

Every year the College sponsors an exchange scholarship with the Technical University in Munich, West Germany. Every year one student from Illinois attends Munich and one student from Munich comes here. Both students receive a tuition scholarship and a stipend to cover living expenses. To apply you must be an honors student or have a grade-point average of 4.0 or above. You must also be a United States citizen and have completed your sophomore year by May.

Applications are made by submitting a letter to a member of the College Honors Council stating why you would like to be part of the program. The application deadline for next year is December 1st. The winner of the scholarship will be selected after interviews with every applicant are conducted. If you are interested, contact Dean Bokenkamp in 207 Engineering Hall.

Engineers Can Jam

Who says engineers don't know how to do anything else but punch their calculators? Tau Beta Pi, the engineering honorary society, is sponsoring a jam session this semester. The event will be "open to everyone to form a diverse group of musicians." Tentatively, the session is scheduled for December 7th from 7PM to 10PM, so mark your calendars. They might even be on the radio!

The Putnam Examinations

Every year the Mathematical Association of America organizes the William Lowell Putnam Mathematical competition. Started as a result of an article written by William Putnam in a 1921 issue of the *Harvard Graduate's Magazine* that described the virtues of academic competitions, the contest has grown to be an annual event.

The examination, which is open to all undergraduates at participating universities, is very difficult. Mathematics professor Bruce Reznick, who helped write the 1985 version of the test, said the problems are not only very hard but also "original" and "aesthetically pleasing." Many very good math students get very low scores, according to professor Harold G. Diamond, who is head of the Putnam organizing committee at this campus this year. He indicated that the two main requirements for success are the abilities to solve tricky problems and to cope with stress. Non-mathematics majors should not be discouraged from taking the examination, though. The test measures the student's cleverness in solving problems more than his knowledge of advanced concepts in mathematics.

The forty-sixth annual Putnam Competition will be held simultaneously at campuses all over the United States and Canada on Saturday, December 7th, 1985. It consists of two three hour sessions, from 9AM to noon, and from 2PM to 5PM. At each session, the students attempt to solve six problems. Prizes are awarded to both university teams and individuals. About 2000 students take the test. The mathematics department holds study sessions for the exam every Tuesday from 4PM to 5PM in 141 Altgeld Hall. Anybody who wants to take the test is strongly urged to attend these sessions. The department will give a mock (practice) Putnam in early November to select the three-person University team.

A good score on the Putnam guarantees recognition as a highly skilled mathematician. High ranking contestants regularly receive graduate fellowships at major universities. Interested students should go to one of the study sessions or talk to professor Diamond in his office at 374 Altgeld Hall.

Bob Janssens

Tech Teasers

1. Biff, a student at the University, just got a new sports car. He tells his friend Dexter, who is a physics major, that he made it go a hundred miles per hour the other day. Dexter sees a chance to embarrass Biff and make some money at the same time. He tells Biff, "I'll bet $50 that your whole car wasn't even moving forward when your speedometer said 100." Biff lost fifty bucks. Why?

2. Here are some sequences. Fill in the missing digits or letters.

a. ABGDE-
b. 12013--42
c. UFDIMPHSBQ-

3. Here is a similar problem. This one requires an answer to an arithmetic statement:

SW + BDDGHSS =

4. Finally, solve this equation. X and Y are digits making up the numbers.

XXX × XXX + XXX = XXXYYY

If you get the answer, show why it is the only answer.

Answers on page 12

Scanning Tunneling Microscope

Scientists at the IBM research laboratory in Zurich, Switzerland have recently developed a new scanning tunneling microscope with a scanning assembly that is small enough to fit in a person's hand.

The scanning tunneling microscope was invented in 1981 by the scientists at the IBM laboratory. It is powerful enough to resolve individual atoms on the surface of solids. The new microscope will have many applications in future technologies as the size of components continues to shrink.

Once objects become smaller than a few hundred atoms in width, their surface composition becomes critical because the surface becomes relatively larger compared to the bulk inside. The chemistry of the surface is different from that of the bulk because surface atoms are not surrounded by other atoms on all sides; therefore, they arrange themselves in a different stable position. The new microscope will be able to look at individual atoms on the surface of materials, such as those used in computer chips, leading to even more miniaturized circuits.

The microscope makes use of a phenomenon of quantum mechanics called tunneling. When two materials are separated by a non-conducting area, there can still be a movement of electrons between the materials if they are close enough together for their electron clouds to overlap. The microscope relies on the principle that this electron current varies tremendously with the distance between the two materials. A very tiny probe scans the surface of a solid from a distance of about 10 angstroms (1 angstrom = 10^{-10} meters). The tip is positioned very carefully so the tunnel current between it and the material being observed is constant. Since the distance is in direct proportion to the current, a topological map of the surface can be obtained by multiple scannings.

The new scanning tunneling microscope is basically a miniaturized copy of the 1981 invention. The whole assembly, including a vibration damping system, fits in a package small enough to use with other microscopes. The original version could not be aimed accurately at any specific points because the area it sees is too small to be located with the human eye. The new version can be put inside another microscope. Researchers can then target an area on a surface through the larger microscope and then zoom in with the tunnelling microscope.

The new microscope, IBM scientists believe, will be very useful in research into the nature of thin films and the surface structure of silicon and germanium compounds which make up semiconductor chips. The new device has also been used in such varying fields as surface science, molecular biology, metallurgy, electronics, and low temperature physics.

Light Wave Communications

In the past few years much attention has been paid to the potential for fiber optics in telecommunications, but only now is the first undersea light wave communication system being tested. A "real world" test system for a planned transatlantic cable was installed in the Canary Islands, a Spanish possesion off the North African coast. AT&T, in collaboration with the Spanish National Telephone Company (CTNE), spanned the seventy-two mile distance between the islands of Gran Canaria and Tenerife with a six-fiber optical cable.

At first the cable will only be used as a testbed for AT&T's planned TAT-8 transatlantic fiber optics cable. Besides determining whether the cable lives up to its design of being able to withstand the high pressures and low temperatures of the ocean floor, AT&T researchers will also cut and try to reconnect the cable. This simulated emergency will help prepare them for an eventual similar occurence with the TAT-8. After the testing has been completed, CTNE will use the cable to carry commercial voice, data, and video signals between the two islands.

Phoning a Computer

Soon it will be possible to have a phone conversation with a computer. AT&T is setting up a new venture to sell the Conversant® Voice System which, according to Thomas R. Thomsom, head of AT&T Technology Systems, will make it so that "The common telephone now becomes a computer terminal, and the human voice becomes a keyboard."

The system uses a combination of voice access, touch-tone dialing, and modems to access a computer. Right now there exist systems that use the touch-tone pad on a telephone as a keyboard, but only half of the nation's phones are equipped with touch-tone.

In its voice input mode, the system can recognize spoken numbers even if the user does not spell out every digit. It is designed to handle these numbers and the words "yes" and "no" in several accents and dialects. The system will be able to be expanded in the future with such options as speaker identity verification and a text-to-speech synthesis feature which enables the computer to read a text to the caller.

Bob Janssens

The Boundary Dynamic

The performance of a polymeric adhesive depends on the properties and composition of its surface. Now a scientist at the General Motors Research Laboratories has developed and validated a theory that describes the coupled effects of diffusion and chemical reaction on the changing surfaces not only of adhesives, but of chemically reacting surfactant systems in general.

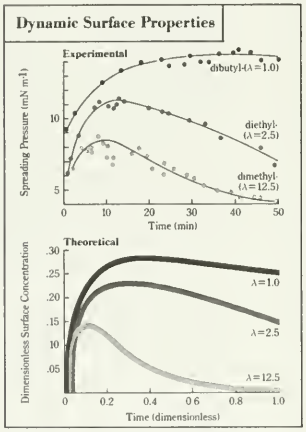


Figure 1: Experimental measurements of spreading pressure v. time for dialkylaminopropylamines with various Damkohler numbers (λ), and corresponding theoretical calculations of surface concentrations.

THE USE OF adhesives in the production of an automobile promises to make both the product and the process more efficient. Both weight and operations can be reduced. In practice, however, steel and other metallic surfaces are often contaminated by process lubricants. A durable bond depends on the ability of an adhesive to displace contaminants and to wet the substrate.

Assuring intimate contact between adhesive and substrate requires detailed knowledge of adhesive surface tension, since it is this property that controls displacement of contaminants and wetting. Up to now the surface tension of an adhesive has typically been assumed constant. In reality, though, surface-active components in the adhesive collect preferentially at the interface and also react, so that the surface composition varies with time, giving rise to dynamic surface tension. Variations can be large enough to significantly affect adhesive performance.

The understanding of time-dependent surface tension has been advanced by the work of Dr. Robert Foister, a scientist at the General Motors Research Laboratories. Investigation of dynamic surface properties of thermosetting adhesives led him to develop a general theory of adsorption kinetics in binary, chemically reacting surfactant systems. The significance of this theory is that it includes the coupled effects of surfactant diffusion and chemical reaction, making it possible for the first time to describe quantitatively the changing surfaces of such systems.

In a typical adhesive that polymerizes, or "cures," by chemical reaction (Figure 2), a surface-active curing agent (Solute 1) reacts with the host resin to form a second surface-active species (Solute 2) that is also reactive. Both solutes migrate to the surface, lowering the surface tension. Diffusion to the surface is driven by a potential energy gradient between the surface and the bulk, with the solute molecules experiencing a lower energy at the surface.

Dr. Foister derived appropriate transport equations to describe diffusion and chemical reaction in the bulk, in a subsurface region, and at the surface itself. The transport equations can be solved analytically if the chemical rate equations are assumed to be first order in the concentrations of reacting species, and if the subsurface and surface concentrations can be related to one another by a linear adsorption isotherm. For more complicated isotherms, a set of coupled, non-linear integral equations is generated.

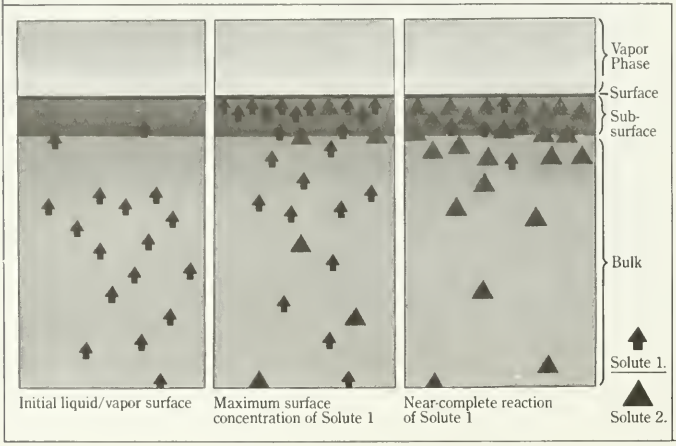


Figure 2: Evolution of an adhesive surface: Surface-active Solute 1 reacts with host resin to form surface active Solute 2.

These must be solved numerically.

Analytical solution for the special case of the linear isotherm indicated that the change with time in surface concentration (and consequently in surface tension) is composed of two terms: first the diffusive flux of Solute 1 into the subsurface from the bulk, and second the depletion of this solute due to chemical reaction. Hence, the surface concentration of Solute 1 exhibits a maximum with time (Figure 2). This maximum in surface concentration corresponds to a minimum in surface tension.

MODIFYING the transport equations to include binary adsorption isotherms allowed for consideration of competitive adsorption of the two reacting and diffusing solutes. By solving these equations numerically and conducting dimensional analysis, Dr. Foister identified various dimensionless parameters as predictors of system behavior. The most important of these parameters was a dimensionless number (λ), of the Damköhler type, involving terms representative of reaction, diffusion, and adsorption.

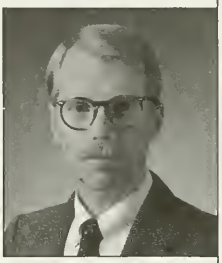
$$\lambda = \frac{k\,(\Gamma_m\, a)^2}{4D}$$

Here k is the reaction rate constant of Solute 1, D its diffusivity, Γ_m its "surface capacity" (the maximum number of molecules absorbed per unit surface area), and a its "surface affinity" (a measure of its energy of adsorption). For an adhesive, lowering λ by reducing k (the reactivity of the curing agent), for example, would prolong the time to maximum, and would increase the value of the surface concentration at the maximum (see Figure 1, Theoretical). As a practical consequence, this would improve wetting by minimizing the surface tension.

In experiments using a series of dialkylaminopropylamine curing agents (dimethyl-, diethyl-, and dibutyl-) in a host epoxy resin matrix, good agreement has been demonstrated between theoretical predictions for surface concentration and the measured dynamic spreading pressure, which is the change in adhesive system surface tension due to the curing agent (Figure 1, Experimental).

"I expect," says Dr. Foister, "that the physical insights gained from this analysis can be applied to other reactive surfactant systems by using specifically tailored isotherms and chemical reaction schemes. Predicting surface behavior can certainly help us design better adhesives for specific applications, but it is also pertinent to the performance of anti-oxidants and anti-ozonants in synthetic rubber, for example. And applied to interfaces in biological systems, a suitably modified theory may prove valuable in understanding the phenomenon of enzyme activity."

THE MAN BEHIND THE WORK



Dr. Foister is a Staff Research Scientist in the Polymers Department at the General Motors Research Laboratories.

Dr. Foister received his undergraduate degree from Guilford College, and holds a Ph.D. in Physical Chemistry from the University of North Carolina at Chapel Hill. His thesis dealt with the role of liquid inertia in the intrinsic viscosities of rod-like polymers.

He did post-doctoral work in Canada as a Fellow at McGill University in Montreal, and in the Applied Chemistry Division of the Pulp and Paper Research Institute of Canada, working on the microrheology of colloidal dispersions.

Dr. Foister joined General Motors in 1980. He is the leader of the Structural Adhesives Group in the GMR Polymers Department. His current research interests center on surface chemistry and adhesion.

Mark A. Stadtherr may be an associate professor in chemical engineering, but his laboratory lacks a bunsen burner. Instead, he specializes in modeling chemical systems using a computer.

Stadtherr first became interested in using computers in his field when he was an undergraduate at the University of Minnesota. He continued his computer work when he did his graduate work at the University of Wisconsin and has pursued his interest ever since he came to the University in 1976.

Rather than attempting to physically set up chemical manufacturing facilities in order to test them, Stadtherr has found that such processes are best tested on a computer. Often each process can be modeled using thousands of equations – work expecially suited to a computer.

Even computers can be too slow for effectively modeling chemical processes. With the arrival of the new Cray X-MP Supercomputer on campus, Stadtherr anticipates using it for even better computer models. The advantages of the supercomputer are several-fold. The increased power of the computer will allow the solving of more complex and therefore more realistic problems. Problems that used to take hours to solve will only take minutes, enabling quicker interaction between man and the machine. With quicker interactivity, better solutions to manufacturing problems will be found.

Students of chemical engineering know Stadtherr for the classes he teaches. Presently he teaches Chem. E. 389, Chemical Process Control; Chem. E. 466, Applied Mathematics in Chemical Engineering; and Chem. E. 469, Special Topics in Chemical Engineering.

When not working, Stadtherr enjoys gardening, bicycling and of course, playing with computers.

Michael Lind

W. Kent Fuchs received his Ph.D in electrical engineering from the University in January of this year. He earned a bachelor's in EE from Duke University in Durham, North Carolina, and a master's in EE from the University. He also holds a Master of Divinity from Trinity Divinity School in Deerfield, Illinois.

Fuchs is an assistant professor and a research assistant. His professorship is in the department of electrical and computer engineering, and his research position is in the Coordinated Science Lab. He also holds a zero-time appointment in the computer science department. This spring he taught a graduate course in EE. Presently he teaches Introduction to Computer Sciences, CS 121, and Introduction to Computer Engineering, EE 290.

Serving on several faculty commitees, Fuchs also enjoys the large amount of research he does. His specialization, reliant computer architecture, includes such things as fault-tolerant computer systems, VLSI chips, and computer-aided design.

Dr. Fuchs says that when he obtained his doctorate, he was faced with two choices, namely, industry or academia. Both offered opportunities for research, his main interest. But academia offered Fuchs an opportunity to teach and work with graduate students. For him, academia was an obvious choice.

After four years of marriage, Dr. Fuchs and his wife, Linda, have a two year old son and a son born on September 20 of this year. His wife, besides raising the boys, is writing a master's thesis in art history for the University of Chicago.

Dr. Fuchs is very active in his church, the Stratford Park Bible Chapel in Champaign. He teaches some Sunday school classes, a college bible-study group, and delivers some of the sermons. He plays pickup basketball games at IMPE, and enjoys reading.

Chris Gerrib

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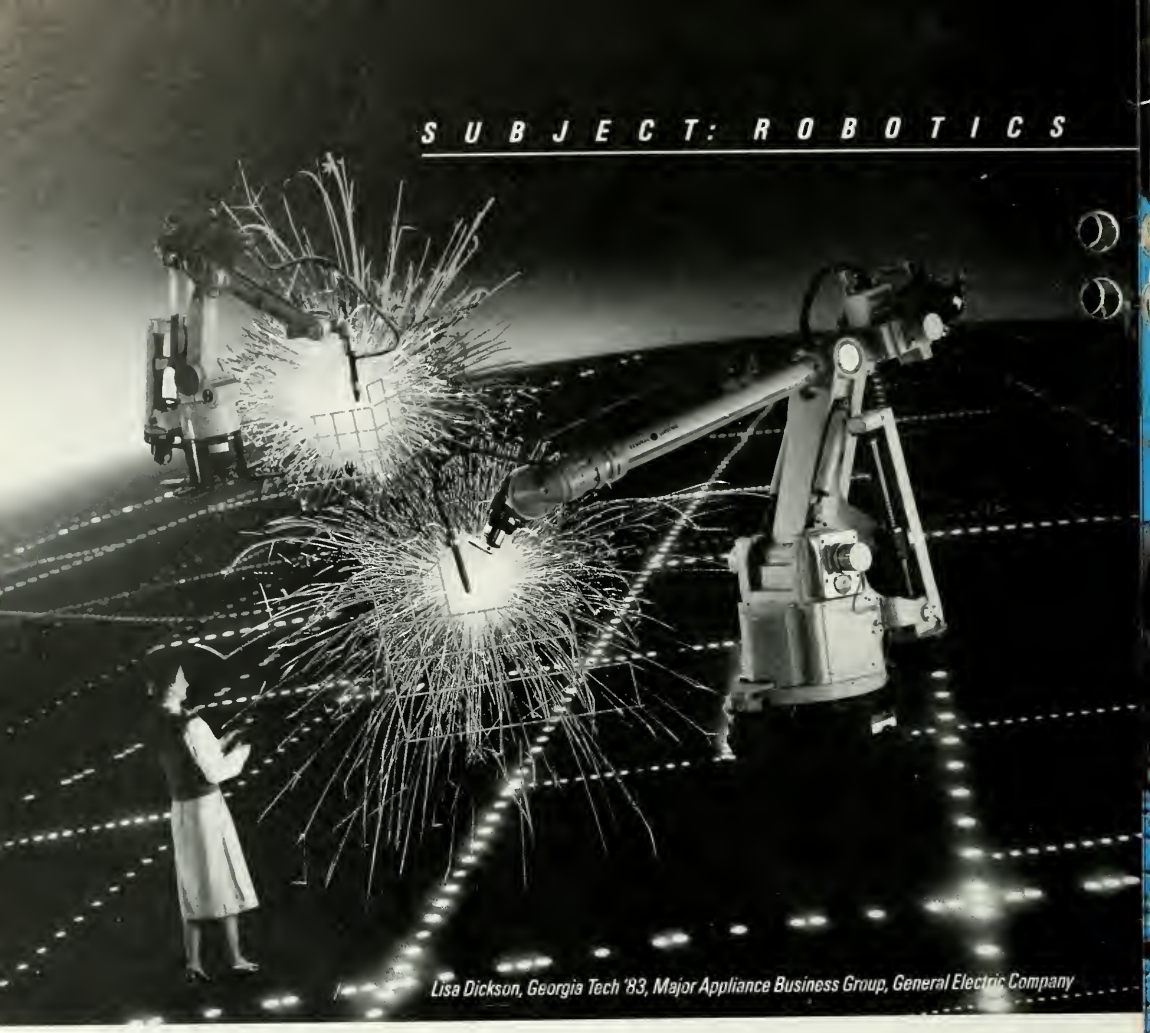

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